Early Journal Content on JSTOR, Free to Anyone in the World

This article is one of nearly 500,000 scholarly works digitized and made freely available to everyone in the world by JSTOR.

Known as the Early Journal Content, this set of works include research articles, news, letters, and other writings published in more than 200 of the oldest leading academic journals. The works date from the mid-seventeenth to the early twentieth centuries.

We encourage people to read and share the Early Journal Content openly and to tell others that this resource exists. People may post this content online or redistribute in any way for non-commercial purposes.

Read more about Early Journal Content at http://about.jstor.org/participate-jstor/individuals/early-journal-content.

JSTOR is a digital library of academic journals, books, and primary source objects. JSTOR helps people discover, use, and build upon a wide range of content through a powerful research and teaching platform, and preserves this content for future generations. JSTOR is part of ITHAKA, a not-for-profit organization that also includes Ithaka S+R and Portico. For more information about JSTOR, please contact support@jstor.org.

A DESCRIPTION OF THE CHANGES IN THE COTTONWOOD LIMESTONE SOUTH OF COTTONWOOD FALLS, KAN.

By J. A. YATES, Manual Training Normal School, Pittsburg.

IN THIS paper I shall describe the changes that I observed in the Cottonwood limestone and some of the changes that were noticed in the formations above and below it. The Cottonwood limestone forms a rather prominent escarpment along the Flint Hills, being about 150 feet below the Wreford limestone, which forms the upper escarpment of what is known as the Flint Hills. Towards the southern part of the state, beginning some fifteen or twenty miles north of Grenola, the Neva[1] limestone thickens up and produces a heavy escarpment from three to four miles to the east, giving the appearance in the topography of two ranges of flint hills. This appearance continues to the south line of the state, the Florena shales and Cottonwood limestone having been entirely eroded from this eastern range of hills, the Eskridge shale covering a large part of the rather broad plateau which connects the two ranges of hills. In a broad way it might be said that the Neva limestone appears at the top of the east range of hills, or the first escarpment, and the Cottonwood limestone at the base of the next escarpment. Throughout the entire course from Cottonwood Falls to the south line of the state the limestone at the top of the Florena shales, and often two other layers of limestone, which occur in the Garrison formation below the Wreford limestone, may be seen. Also, the upper, middle and lower Neva limestones appear in the formation below and seem to be continuous.

Some of these formations change greatly in their lithological characters as one follows them south. Also, rather strong anticlines are noticed at the divides between the river systems, and synclines at the heads of these streams. This is especially noticeable along the divide between the Verdigris and Fall rivers, where the dip is about 1°. Also, near Derry, now called Blodgett, the dip is 2°; as the streams run east, in the main, the dip on one side is to the north and on the other to the south.

While the lithological characters of the Cottonwood limestone change many times in the territory mentioned, the Florena shales remain more constant in character than any other formation near it. The limestone at the top of the Florena shales forms a conspicuous escarpment at Grand Summit, forming the massive limestone through which the Santa Fe railroad passes about a half mile east of the station. This rather marked escarpment continues on to the south, and at Hooser it is seen at the base of the escarpment, east of the depot. The railroad crosses this layer about one and one-quarter miles south of the Hooser station, and it forms a prominent escarpment around the schoolhouse, in section 11, township 34, range 7, the top of which is seventy feet above the limestone appearing in the branch near this schoolhouse. I believe this layer in the branch to be what I have called middle Neva. This limestone at top of Florena shales continues to the state line. During the last six miles it seems to be disappearing and layers of sandstone to be taking its place, making it somewhat difficult to map.

---

[1] For description and nomenclature of the formation in this paper as they appear at other points in the state, see Cottonwood Falls Folio, No. 109, U. S. Geological Survey.

The Cottonwood limestone, as it appears in the large quarries east of the town of Cottonwood Falls, is a massive layer of limestone about six feet in thickness. About two and one-half feet from the top surface of this limestone appears a layer which is full of holes. The quarrymen split this massive limestone horizontally at this place The upper part is very full of *Fusulina*, while the lower part contains very few. The general appearance of the two layers, were it not for the *Fusulina*, is the same. This limestone is quite soft when first quarried and weathers very slowly and evenly, thus making it one of the best limestones for economic purposes in the state, it being quarried and sawed near the town of Cottonwood Falls and shipped in large quantities to various parts of the state, where it is used for building purposes.

The Cottonwood limestone is found near the top of the hills around Bloody creek. The eastern escarpment appears just west of Jacobs creek, passing on to the east line of Chase county; then running almost due south, near the western line of Butler and Elk counties, into the eastern part of Cowley county, where the formation entirely disappears about seven miles north and a mile east of Hooser.

This formation north of Cottonwood Falls, according to the U. S. Geological Survey and the statements of the state geologist, has as distinct and clearly defined lithological characteristics as any limestone in the state. These distinct characteristics continue in this layer until, following the outcrop along to the east side of Jacob's creek, for the first time changes were noticed in it, and which continued throughout the course of the escarpment until the stratum entirely disappears at the point noted above.

For some fifteen or twenty miles north of the point of the complete disappearance of the Cottonwood limestone it becomes so changed as to make very little escarpment, and had it not been for the limestone at the top of the Florena shales forming a prominent escarpment it would not be possible to map the Cottonwood as far south as mentioned.

A section of the formation as it appears on the east-and-west road, three miles east of Cottonwood Falls, on the east side of the south fork of the Cottonwood river:

About 100 yards to the south of the road, on top of the hill, the Cottonwood limestone is nicely exposed in a small quarry.

7. The shale is well seen in the road; has first three to five feet of yellow shale, four to five feet of greenish-blue shale.

6. A very red fossiliferous lime, one foot thick, probably not a continuous formation.

5. One foot in clay.

4. About nineteen feet of blue shale to the Neva limestone. The latter is composed of layers of limestone with shale between. The thickest layer is about two feet thick.

3. A foot of shale.

2. Two feet of limestone. Only two massive layers are seen in the Neva lime. The appearance of the fracture of this limestone is bluish in color and quite hard; fossils are scarce.

1. Forty-eight feet of a yellow shale down to the flood plane of the river.

On the east side of the south fork of the Cottonwood, in the northwest quarter of section 23, township 20, range 8, a very high cliff is found. The Cottonwood limestone makes a very characteristic layer here, and sixteen feet above it is a stratum of limestone twelve to fifteen inches thick, which breaks up into massive blocks, weathering in appearance very much like the Cottonwood. When broken it contains reddish crystalline particles. This layer seems to have thickened up somewhat here, it being the limestone at the top of the Florena shales. On the east of Sharp's creek, in section 34, township 20, range 8, we find the lime above the Cottonwood at least three feet thick, massive in appearance and forming a prominent escarpment. It still has its characteristic blue and red particles and weathers in holes. The Cottonwood limestone is very near the bank of the creek.

In the southeast quarter of section 25, township 20, range 9, at the head of Jacobs creek, near the Chase county line, the Cottonwood for three miles north makes comparatively little escarpment, the ironweeds marking its course; the *Fusulina* layer becomes much softer; the other layer has the characteristic color, but appears as flagging. The lower layer has the appearance of the top layer of the Neva. The rather porous layer in the Cottonwood limestone seems to be displaced and a rather hard sort of violet-striped layer has taken its place. In the southeast quarter of section 30, township 20, range 10, in Lyon county, the *Fusulina* layer has disintegrated and only the shells are left. In this same section some flint is noticed in the Cottonwood formation. To the north and east of Mrs. Saunders' home, in section 30, township 20, range 10, some flint is noticed in the Cottonwood limestone, and here the *Fusulina* are again scarce. The flint is found imbedded in the limestone, which appears to be "shelly," weathering into very small pieces, usually breaking into flat "rubble." In the southeast quarter of section 20, township 20, range 10, the Cottonwood limestone has almost disappeared, except in ravines. In a ravine near the half-mile line it is about four feet thick, very "shelly," very few *Fusulina*, the chert increasing quite rapidly. As seen at a stock pond to the west, the outcrop of it would give the appearance that one-half of the formation is chert. In sections 20 and 29 the limestone is largely covered with soil, but its presence is evident from its occurrence in ditches, the calcareous flint increasing. Between sections 29 and 30, in the north-and-south road, it may be readily seen that much chert is just above this lime. Following the escarpment around through sections 30, 19, 20, 29 and 31, township 20, range 10, section 36, township 20, range 9, and section 1, township 21, range 9, the outcrop of the Cottonwood limestone in all of these sections is very inconspicuous. At places at the head of ravines and ditches the formation is seen, but very little escarpment is made by the limestone formation; and this being the large divide between the Cottonwood river and the Verdigris river, the outcrop of the formation here is quite different from the outcrop of the same formation to the north and west. The region is a high plateau, and were it not for the Nevas below it would be almost impossible to trace the formation across this plane.

There are three somewhat conspicuous limestone strata that are noticed below the Cottonwood. The one just below the Cottonwood limestone has been described above. The middle one, some fifteen to twenty feet below the upper Neva, is usually made up of three layers of limestone, separated from each other by one to three feet of shale. The middle layer in appearance is very much like the Cottonwood, the lower and upper layers being harder and of a bluish color. Below this middle Neva some fifteen feet is a layer of limestone that I have called the lower Neva. It is a very impure limestone, containing large quantities of impurities. Some parts of it are very soft and others quite hard, thus giving the weathered exposure a very rugged, honeycombed appearance. The outcrop of these Nevas is very conspicuous around Bloody, Spring and Jacobs creeks. On the west side of Jacobs creek, in section 14, the lower Neva is exceedingly rough and honeycombed in appearance. As we go south this continues throughout a number of sections, and then it appears much more homogeneous in character, to again become rugged and change its lithological characteristics. The changes in the various limestone formations from the head of Jacobs creek to the south line of the state, both above and below the Cottonwood, are very noticeable and exceedingly interesting. However, they maintain a constant vertical relation. Across a very level plane extending east through section 2, township 21, range 9, it is impossible to follow the outcrop of the Cottonwood limestone, but by its relation to the limestones above and below it may be mapped, since south of this point the formations are identical with those north of it. The Cottonwood limestone is normal in appearance where exposed, except the upper part seems to have become much softer and to have disintegrated more readily, consequently giving very little escarpment. Where the limestone could be seen in the ditches the *Fusulina* were found in large quantities in their proper place, and serve as an excellent means of locating the formation. Where the Verdigris river has cut back to the west, and the formations above the Cottonwood are exposed, its outcrop becomes normal. The dip to the south from section 31, township 20, range 10, is quite noticeable, being between 1° and 2°. In section 11, township 21, range 9, near a windmill, the Cottonwood lime has been quarried, and appears normal, save near the bottom of it, where it is noticed to be somewhat molluscan (containing shells of Mollusca). For some distance here the Cottonwood appears normal. In the northeast quarter of section 27, township 21, range 9, it has lost many of its normal characteristics. The molluscan layer has increased greatly in size until about one-half of it is of this character. The *Fusulina* seem to be few; the lime is blue in appearance, though the texture is the same; the hardness normal. The *Fusulina* layer seems to have become very soft on account of the addition of mud in its formation. Where seen it is very rotten, and blue in color. Some layers are seen in the formation that when broken have a crystalline appearance, and are much harder than the normal Cottonwood. At the head of a deep ravine in section 22, township 21, range 9, where the talus has recently tumbled down in massive boulders on the underlying shale, there are about two feet of massive stone, very much like the lower layer of the Cottonwood, except bluish in color. The texture is normal. Then comes eight or ten inches of this violet-colored lime. The violet color is in lines, as though it were made of a conglomeration of shells. These violet lines are harder, as shown by the way it weathers. Above this is a four-inch layer of knotty ironstone; then what corresponds to the porous layer in the normal Cottonwood; then a *Fusulina* layer, which is very soft.

In section 3, township 21, range 9, the limestone at the top of the Florena shales has become much thicker, with a rather bluish tinge, very hard, containing iron, nonhomogeneous, and hence erodes with very jagged appearance. The *Fusulina* layer of the Cottonwood limestone at this place is little more than calcareous shale. Near the head of the Verdigris, where the stream cuts through it at a high bluff, the Cottonwood limestone appeared three feet above low-water mark. Here the lower layer is massive, about four feet thick. The top part of this four-foot layer for about one foot is filled with *Fusulina.* The calcareous *Fusulina* shale above graduates into a blue shale filled with *Fusulina,* so that it is very difficult to find the dividing line between the Cottonwood limestone and the Florena shales. The Florena shales are nicely seen at this place, with their characteristic fossils. The hard violet layer is not seen in the Cottonwood limestone here; neither is the portion which is filled with holes, that separates the two massive layers. The stratum seems to be of a very bluish appearance, and probably of economic value. None of it would be of value unless it be the lower three feet. The upper part disintegrates like shale. The fossils in the blue slaty shale above appear in layers for a thickness of eight or ten feet. A small ravine through the cliff enables one to see clearly the layers above as well as the Cottonwood.

The lithological characteristics of the formation are entirely different from the Cottonwood limestone at Cottonwood Falls. In the northeast quarter of section 2, township 22, range 9, in a ravine where a good showing of an outcrop is found, we find the hard violet layer becoming harder and larger; the massive blue layer beneath this being blue, and the *Fusulina* layer still shaly. The formation runs regularly in composition for several miles on the east and south side of the Verdigris river, making a well-defined escarpment, the *Fusulina* layer only appearing in ravines. Usually the shells may be seen in the dirt just above the exposure. The hard *Fusulina* layer is in evidence for several miles north, the flint having disappeared. Running out northeast from section 7 into section 5, township 22, range 10, is a plane a mile and a half to two miles long. In the northeast quarter of section 5 a small patch of Cottonwood limestone is found. To follow the limestone across this plane is again quite difficult. Only the harder part of the stratum is left, on account of the erosion having been very slow.

Here again one must rely largely upon the formation above and below in order to follow the Cottonwood. Near the section line of section 8, township 22, range 10, is a long, very gently sloping ridge. On the highest part near the east line, say one-fourth of a mile from the east line, occurs the Cottonwood limestone; but only a few acres, at most, and in a very narrow line. The ridge is covered by chert, the limestone being mostly gone. More chert seems to be here in the upper half of the limestone. No solid limestone that contains *Fusulina* is seen for many miles to the north. The upper and middle Neva limestones have changed in their outcrop from what they were to the north.

About the center of section 18, township 22, range 10, a large cliff gives a good exposure of Cottonwood limestone, and here the formation is only about two and one-half feet thick, blue in color instead of yellow, but with the texture of the Cottonwood line. Chert is seen in all parts of the formation. The *Fusulina* part seems to be nothing but shale. The fauna of the Florena shales is nicely seen here. The line at the top of the Florena shales is quite hard, while in appearance it resembles the lower Neva, except some very large molluscan shells are found in it. This stratum is thick enough to make a good escarpment for some six or eight miles north of this point. The escarpment around the two branches of the Verdigris may be easily followed, but it is quite difficult to cross the divides, because here the land lies in the form of a plane, and when the formation is seen, on account of the very slow weathering and erosion only the hardest and most irregular parts of it are left. The appearance of the land is such as to deceive one greatly. The Cottonwood limestone runs far up on the main escarpment of the Flint Hills, the creeks all having a very great fall; and often just where the limestone crosses a ravine is the only place where you can drive across. The velocity of the water is so great that great quantities of rock are brought down that weigh from a few to 50 or 100 pounds. Often holes are cut out in the bed of the stream where the water pours over the harden limestone, and this affords most excellent places to study the recently eroded formations. Often the head of the creek is from one-half mile to a mile above the Cottonwood limestone, and the made land covers it near the heads of the creeks in such a way that it is hidden on one side of the creek, with usually a bluff on the other, which will enable one to see exactly where the creek has cut through, and affords excellent exposures. The Cottonwood limestone through this section of the country is blue instead of yellow in appearance. The upper Neva is quite in evidence around the main Verdigris, and on Camp creek appears as good flagging. On the South Fork it is not noticeable. The middle and lower Nevas are very heavy and still have their characteristic appearance.

In the southeast quarter of section 29, township 22, range 10, there is an outcrop, probably of a quarter of an acre, covered with Cottonwood lime. In the southwest quarter of section 29, township 22, range 10, at the head of a ravine, the *Fusulina* are very noticeable, lying in the blue shale that is in the place of the *Fusulina* layer of the Cottonwood limestone. Here may be noticed crystals of calcite. Fossils, such as crinoid stems, appear all through the formation. These fossils may be noticed for some miles towards the north, but are more pronounced at this place.

In the southeast quarter of section 29, at a high embankment, six feet below the Cottonwood limestone a calcareous shale two feet and four inches thick appears. It is quite hard and makes a prominent feature in the cliff. A similar shale in the same position is found in section 11, township 22, range 9. The Cottonwood seems to be homogeneous and about two and one-half feet thick; yet at the head of the creek on the north side of section 5, township 23, range 10, the Cottonwood appears very massive, but it weathers like shale. In two places it is well exposed in the creek bank. It breaks up into flagging from one to two inches thick, with an area of two or three square feet. In sections 9 and 8, township 23, range 10, the dip is very great to the west. In a little less distance than three fourths of a mile it is forty-eight feet; measured in degrees, about one. In section 28, township 23, range 9, the layer above the Cottonwood seems to be mixed with Cottonwood lime. The Cottonwood lime is well exposed in a number of ravines here. Little white shells are seen laminated through the limestone. In a rather large layer, four inches above the bottom, a three-inch layer of shells occurs. This laminated layer has thickened up in the Cottonwood lime until it has become a large part of it.

A good exposure is seen in a ravine northwest of a house which is in the southwest quarter of section 28, township 23, range 9. Here some four inches of the bottom layer of the Cottonwood seems normal blue Cottonwood lime. Above this is a hard layer of fossiliferous stone, which weathers into a very rough flagging lime hard, flinty and useless, with no appearance of the Cottonwood lime. The stratum through this section of the country is quite irregular in its outcrop and appearance but it makes a good escarpment, very easily followed.

Much of the weathered rock has a yellow appearance and contains holes in it like the middle Neva. Then it appears again as red hard lime, resembling the lime at the top of the Florena shales. The "shelly," violet-colored layer seems to have changed into the impure part of the stratum and has become a large part of the formation. The hard calcareous shale described above, occurring just below the Cottonwood line, in some places contains enough grit to be used for whetstones, though no analysis was made of it. By its constant appearance, always in the same vertical position, it serves as a guide in following the Cottonwood limestone.

The *Fusulina* part of the Cottonwood limestone still appears, but seems to be a little harder here than farther north; yet it weathers as shale. In section 8, township 24, range 9, at the head of a ravine, the impure layer, which is near the bottom, has holes in it and weathers so that the outcrop appears like the lower Neva. This part of the stone is ten to twelve inches in thickness. There is still a small amount of the molluscan layer, and *Fusulina* in the dirt above.

In section 16, township 21, range 9, the Cottonwood lime weathers into a very checked honeycombed structure, and when broken part of it contains small cavities filled with a red material. This layer is the same near the lower part of the stratum. The formation here, however, is at the very top of the divide, on Colonel Bailey's ranch, between the east and west branches of Fall river.

In section 20, township 24, range 9, the honeycombed layer measured at one place eighteen inches in thickness. Below this layer are about six inches of the blue Cottonwood lime. As we go west into the synclinal valley of the west branch of Fall river it is quite noticeable that the topography of the country changes. The formations above the Cottonwood limestone have been cut away and the hills appear to be not so high, and from the topography one would judge that it would be easy to drive across the escarpment. In the southeast quarter of section 12, township 24, range 8, great massive boulders are seen, three feet thick and very nearly homogeneous, honeycombed in structure, and forming a most pronounced escarpment. The rocks are filled with red granules, which are quite soft, and these wash out, thus causing it to weather in holes. No special part of this layer is more honeycombed than the other, to judge from what can be seen from the boulders.

Above this three-foot layer is one of about six inches, softer and with hard streaks running through it, looking as though half the volume of it was made of some sort of large shells, but so worn as to be incapable of classification. It seems to be a layer of coquina. Above this layer we find another layer about one foot to eighteen inches of typical blue Cottonwood limestone containing crinoid stems, and an abundance of *Fusulina* is seen in the dirt above. The hardness and general lithological character of the layer of Cottonwood seems perfectly normal at this point. The *Fusulina* are in the dirt just over this layer, but do not occur in the rock for many miles to the north.

In the southeast quarter of section 3, township 24, range 8, the honeycombed layer seems to have grown much less, while the normal Cottonwood appears to be a much larger part of the formation, which is well seen here in a large cliff, and there is from one to one and one-half feet of normal limestone, like the lower layer at Cottonwood Falls. Abundance of *Fusulina* is in the dirt above. The remainder of the limestone is still the impure variety, but erodes more readily, thus allowing the Cottonwood part to appear on the outcrop. In section 16, township 24, range 8, on the west side of Cat creek, the line at the top of the Florena shales has thickened up and forms a very prominent escarpment.

Fall river seems to be in a synclinal valley running northwest and southeast. On the south side of Ivanpagh creek the dip is northwest about 40′. At a stock pond in the southwest quarter of section 18, township 25, range 9, a little north and east of Sugarloaf, the Cottonwood lime is nicely seen in a ravine. The shelly kind is at the top; the bottom part is very hard, yellow, and somewhat different from the massive. In the southwest quarter of section 16, township 26, range 8, at a big spring and ravine, the Cottonwood lime has changed at the top to a very yellow color, with the normal texture. The *Fusulina* is seen in the dirt, but none could be found in the stone. The Florena shale fauna is nicely seen here. The formation makes a prominent escarpment for many miles to the north, the outcrop being massive boulders, honeycombed, rough, jagged in appearance. The top part of the limestone seems to be not perfectly homogeneous, but softer spots appear in it and some black dots. The honeycombed layer is three and one-half feet thick, and when broken probably half of it is so soft that it may be cut with a knife, like chalk. The other part is quite hard. The impure nodular layer is about one foot in thickness, and the Cottonwood part about six inches, the shale above containing *Fusulina*. On the south side of section 3, township

27, range 8, near the head of Spring creek, the coquina layer has become a calcareous shale, very yellow, with about six inches of Cottonwood limestone above it. Very few *Fusulina* are seen in it.

Coming around the divide between Spring and Otter creeks, the outcrop becomes more like the normal Cottonwood lime. It erodes smoothly and has the texture of the Cottonwood lime; when the honeycombed layer is examined the fracture reveals the fact that the molluscan layer has become crystalline. The appearance of the stratum here is that it is repeatedly changing to normal Cottonwood lime. A large part of the stratum here would serve for building purposes. The fauna of the Florena shales is well seen at this point; also the calcareous shale below the Cottonwood lime. The layer at the top of the Florena shale has changed decidedly in appearance. It now has the fracture and texture of the Cottonwood lime in hardness and general lithological characters, and forms as prominent an escarpment as the Cottonwood, its vertical position being unchanged. Also, the Nevas at this place make prominent escarpments.

In the northwest quarter of section 2, township 28, range 8, the Cottonwood lime is well shown in a cut on the Frisco railroad. The limestone measures five feet eight inches in thickness:

5. The upper part, two feet 4 inches in thickness, has the usual appearance of the Cottonwood lime. Some *Fusulina* are seen in it and some crinoid stems. The color is tinged with red instead of yellow, but has the texture of the Cottonwood lime.

4. Below this is a soft, shaly layer of from one to two inches in thickness.

3. The layer of stone that I have described above as the violet molluscan shows clearly the shells of which it is composed, at the weathered surface. It also has red specks of iron in it. Thickness, eight inches.

2. A very thin lamina, less than one-fourth of an inch in thickness.

1. The basal layer, two and one-half feet in thickness, is a more conglomerate-looking stone, as though it was made up of much larger shells. This is the part that causes the rough, rugged boulders to the north. The limestone at the top of the Florena shales is still somewhat prominent and has a good deal of the appearance of Cottonwood lime, except that the *Fusulina* are at the bottom.

In the northeast quarter of section 11, township 28, range 8, the Cottonwood limestone appears on two very small mounds—probably an acre in the west one, and still less in the one to the east—the limestone being the top layer of each mound. The dip to the southeast is a little less than 2°.

Quite a narrow syncline is noticed between the two ponds by the railroad, a litle west of Derry, or Blodgett. This synclinal fold may be seen distinctly by beginning at the railroad cut, already described, and following the outcrop, which is mainly south to the head of the ravine on the west side of section 11, to where the road crosses the ravine and a big spring comes out of the shale below the Cottonwood limestone. At this place the layer on the east side of the ravine is much lower than on the west side, and if followed its outcrop passes near by the railroad pond, reaching nearly to the surface of the water of the west one, the fall here being some fifty feet in a half mile, about 2° dip. Following it around a sort of mound, we find it on the north side of the railroad track, fifty yards west of the water tanks. The limestone over the Florena shale appears at the railroad crossing. The Cottonwood appears just west of the cut at the pond, and may be seen in the outcrop to the west and northeast. The outcrop may be seen on the hill just east of the pond, forty feet above the water level. Here the dip is to the west, the opposite of the way it is at the east pond. The railroad runs northeast and southwest near the center of section 11, township 28, range 8. This appears to be a synclinal valley about a mile wide, running northeast and southwest. It is nearly two miles from outcrop to outcrop of Cottonwood.

After crossing the divide to Elk river *Fusulina* appear in the limestone at the top of the Florena shales, especially the lower part; the stone is soft and yellow in appearance, quite like the Cottonwood limestone. At the head of Elk river this formation is seen nicely in a quarry, and here the lower part of it is quite impure. Near where the Elk river cuts through the Cottonwood limestone an excellent bluff for studying the layers is found. Here the stratum of Cottonwood limestone is found to be five and one-half feet thick, the dirt above being filled with *Fusulina*. This stratum breaks up here into boulders resembling the normal Cottonwood limestone at Cottonwood Falls. Further north the bottom part of the stratum shows on the outcrop rugged and rough, the top part maintaining more of the appearance of normal Cottonwood. The underlying calcareous shale, which is conspicuously noticeable to the north just beneath the Cottonwood limestone, seems to have become an impure limestone, very hard, containing iron, and sometimes described as "knotty."

Between sections 30 and 31, township 29, range 9, an examination of the limestone being made at the head of a small creek running into Elk river, two layers of limestone appear above the Cottonwood to the top of the hill, the rugged and the flagging layers both making some escarpment, but not very marked, the flagging layer being the less noticeable of the two. From the railroad cut described to the north the limestone above the Florena shale has become more and more pronounced, until from six miles or more north it makes a much more prominent escarpment than the Cottonwood limestone. The appearance of the Cottonwood limestone on the escarpment, where it may be seen, is nodular, shelly and shaly-looking (not distinctly shaly, but weathering somewhat that way). An examination at the point above mentioned shows the Cottonwood limestone, which can be seen only in places, to be about two feet thick, bluish in color, breaking up into flagging nodules without seams, *Fusulina* occurring. The Florena shales can be well observed here, containing the characteristic fossils, this being an excellent place for collecting. The limestone overlying the Florena shales measured fourteen feet in thickness and consists of a fossiliferous layer containing *Fusulina*, crinoid stems and many molluscan shells, weathering into the appearance of flagging, the thickness of which is two feet, the lower ten or twelve inches being fossiliferous. Above this part the limestone appears in layers of yellow lime, easily eroded, containing soft layers, causing the weathered appearance to be that of massive blocks. This massive layer is fully nine feet thick at this place. Some of the layers weather into jagged, knotty, irony lime, which appear on the outcrop. No fossils were found in any but the lower layers.

A layer of clay occurs just above this limestone for several miles and causes many springs, giving it the appearance of springs almost on top of the hill, and the ravines are very rugged. In the main there are two massive layers of this limestone, with a more or less easily eroded layer between them, the lower layer weathering into jagged, honeycombed rock, which appears on the outcrop. A few feet below the Cottonwood limestone a bluish-looking lime of one and a half feet in thickness continues, this being the limestone that has taken the place of the calcareous shale further north.

On the Santa Fe railroad, west of Grenola and for many miles to the north, the lime above the Florena shale makes a very prominent mesa. The Cottonwood limestone makes a very inconspicuous one, which is continuous, but is usually the same as a small step just below the prominent one. The outcrop of the Cottonwood limestone appears nodular; the shale above it is more conspicuous than the limestone. Many small ravines in it afford excellent opportunity for observing its characteristic fauna, which occur in great abundance. The railroad cut about a half mile east of Grand Summit, at the top of the hill, is mostly in the shale above the lime which is above the Florena shale. The cut and quarry in this limestone afford an excellent opportunity for studying it. This limestone appears columnar on the outcrop. On examination it is found that the layer next to the top one is about two feet thick, weathering in such a way as to give it this appearance. Just below the columnar layer is one two feet thick which weathers very white, and in the quarry on the north side of the railroad near the cut is seen to be a white crystalline lime.

The columnar layer breaks up on the outcrop, looking as if it had been blasted away. The railroad runs over the Cottonwood stratum of limestone without making any cut in it. The layer of blue, hard calcareous shale seems somewhat thicker at this point and makes a layer which could apparently be mapped. The Cottonwood limestone at this point is two or three feet thick, very nodular, with seams of shale running through it, the thicker layer less than two feet. The Cottonwood limestone runs into Cowley county a mile and a half north of the north line of Chautauqua county, in the Otter creek basin. In this basin the hills have flattened down, the escarpment being much more difficult to follow.

In the southwest quarter of section 19, township 30, range 8, just south of the place where a house formerly stood, the remnant of the Cottonwood limestone is seen to be a knotty, hard layer, having the appearance of a temporary limestone. No outcrop of the Cottonwood limestone can be seen for at least two miles north. The limestone above the Florena shales makes a less notable escarpment, but this limestone thickens up to the south.

In the southwest quarter of section 30, township 32, range 7, toward the head of a long branch running into Otter creek, a rather high bluff is seen on the east side of the stream with several sycamore trees around it, and in this bluff the only trace that could be found of the Cottonwood limestone is little knotty streaks of limestone through the shale, a clay shale being between every streak, and fossils found in it, and chunks of hard, blue, rotten, shaly limestone. The fossils common to this horizon found in the shale are sometimes in the limestone. The tops of these layers (if such they may be called) are horizontal and in regular lamina, which are separated from each other by thin layers of clay shale. The lamina of limestone are not continuous, but are separated vertically every few feet by patches of shale. The shale above this streak is pure Florena shale seven or eight feet thick. The limestone above the Florena shales begins with layers of shelly streaks of lime. From the top of the upper streak of Cottonwood limestone to the first solid continuous layer of limestone above the Florena shales is nine to ten feet. From the appearance of the streak of fossils and nodules of limestone where the Cottonwood limestone would normally appear, I should say that when this material was being deposited that it was near a coast line, and the different layers of shells, followed by shales, would clearly show that the animals had been killed by the overflows of mud. Then the water becoming normal again and teeming with life, again overflowed. Finally the sea became deeper and the Florena shale was deposited; then the shelly layers of impure limestone, and finally the deeper waters for the formation of the heavy limestone at the top of the Florena shales. The Cottonwood limestone makes no outcrop for several miles to the north; the limestone at the top of the Florena shales making an outcrop which is fairly easily followed, and its nearness to the Cottonwood limestone, makes the mapping of the one practically the mapping of the other. On the west side of the creek above described, in many deep ravines coming into the creek for a mile or so, frequently the same formation as described above is found.

CONCLUSIONS.

It would appear from the facts observed in the changes in the lithographical structure of the Cottonwood limestone that the outcrop of this formation was near the margin of the sea at the time the material was laid down. The first change noted being in the top part of the layer, and it gradually becoming more and more shaly, would indicate that the land was rising here to the east of the most eastern outcrop near the head of Jacobs creek, and that before the stratum was completed the water was filled with mud, thus in this way producing the shaly limestone at the top. It was generally observed that where the creeks cut far back to the west the limestone was more normal in its characteristics. The chert in the limestone would indicate that it was formed near the margin of the sea. From the manner in which the chert is found in the formation it is evident that it was deposited in the layer while it was in the process of being formed. The highly fossiliferous shale immediately above the Cottonwood limestone certainly shows the land to have been rising and to have come above the depth for the formation of the limestone, and the life to have been exterminated by the muddy deposit now forming the Florena shales. The lithological characteristics of the layer after passing into the Verdigris and farther south, where the molluscan part of the layer disappears, strongly reminds one of coquina as formed on the Florida coast to-day. It is this molluscan layer that changes into the layer containing much iron and made up of materials which in some places are very hard and in others very soft, and when exposed by erosion causes the stones on the outcrop to appear very rugged and rough, and finally, where the limestone displaces it, gradually becoming thinner and thinner; streaks of shale divide it into different layers, and finally the shale replaces it entirely, the streaks of limestone becoming merely little, thin layers of shells, the shells being perfectly preserved in the shale.

If the Neva limestones and the one at the top of the Florena shales be considered as part of the Cottonwood limestone formation, then this limestone continues, south of Hooser into Oklahoma, in the limestone described as Neva in this paper.